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**The Design of a General
Repair Shop for Locomotives**

Railway Mechanical Engineering

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THE DESIGN OF A GENERAL REPAIR SHOP FOR LOCOMOTIVES

BY

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THESIS

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IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

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THE DESIGN OF A GENERAL REPAIR SHOP FOR LOCOMOTIVES.

The railway repair shop as described in this thesis was located at Champaign on the assumption that the Illinois Central Railroad purchased the Peoria and Eastern division of the Big Four Railroad. The main shops of the Illinois Central are located at Burnside, Ill., near Chicago, and the existence of the shops of the Peoria and Eastern at Urbana, Ill. was neglected.

Champaign is located on the main line of the Illinois Central, one hundred and twenty-eight miles from Chicago, and about midway between Indianapolis, Ind. and Peoria, Ill. on the Peoria and Eastern division of the Big Four Railroad. It is also the terminus for one branch line. Its location being somewhat the "center of gravity of traffic" of the district served, makes it a desirable place for a division point and a repair shop.

There are other considerations favorable to the establishment of the shops at Champaign. It is near Chicago, one base of supplies, and this section being a prosperous one, a desirable class of labor can be obtained.

GENERAL CONSIDERATIONS.

The shop site having been chosen and the land provided, the character and quantity of the work to be done in the completed plant was determined. The shops were proportioned on the basis of the greatest output likely to be required during any one month of the year.

It appears to be the general policy of the Illinois Central Railroad to buy its engines in quantities of twenty to forty in

order to get advantageous prices and to maintain standards. These are delivered in monthly installments by the manufacturer, covering a period of six or eight months. As engines of a certain class and service on a given division will generally cover about the same mileage before it is necessary to send them to the shops for repairs, the engines will be ready for the shop covering a period as received. Thus the shop will not be overcrowded at any one time as would be the case where all engines are put in service at the same time. At the present time, on the Illinois Central and Big Four Railroad, there are two hundred and sixty engines of all classes in the districts served by the Champaign shops. An engine may be expected to run about eighteen months in these districts before requiring general repairs. With up-to-date methods this should take a little less than three weeks. Each pit will then turn out three engines every two months, giving a required maximum shop capacity of thirty-three engines per month, ^{Since} These shops are ^{also} to handle any overflow from the Burnside shops, but are designed for both heavy and light repairs, especially the latter, most of the heavy repair work and manufacturing being done at Burnside.

SELECTION OF A SHOP SITE.

In the arrangement of the different departments of the shops, several things were kept in mind and as far as possible were carried out in the general layout.

LAND AVAILABLE.

Several hundred yards north of the crossing of the Big Four and Illinois Central Railroads, on the east side of the Illinois Central tracks, houses are scarce and property is not expensive.

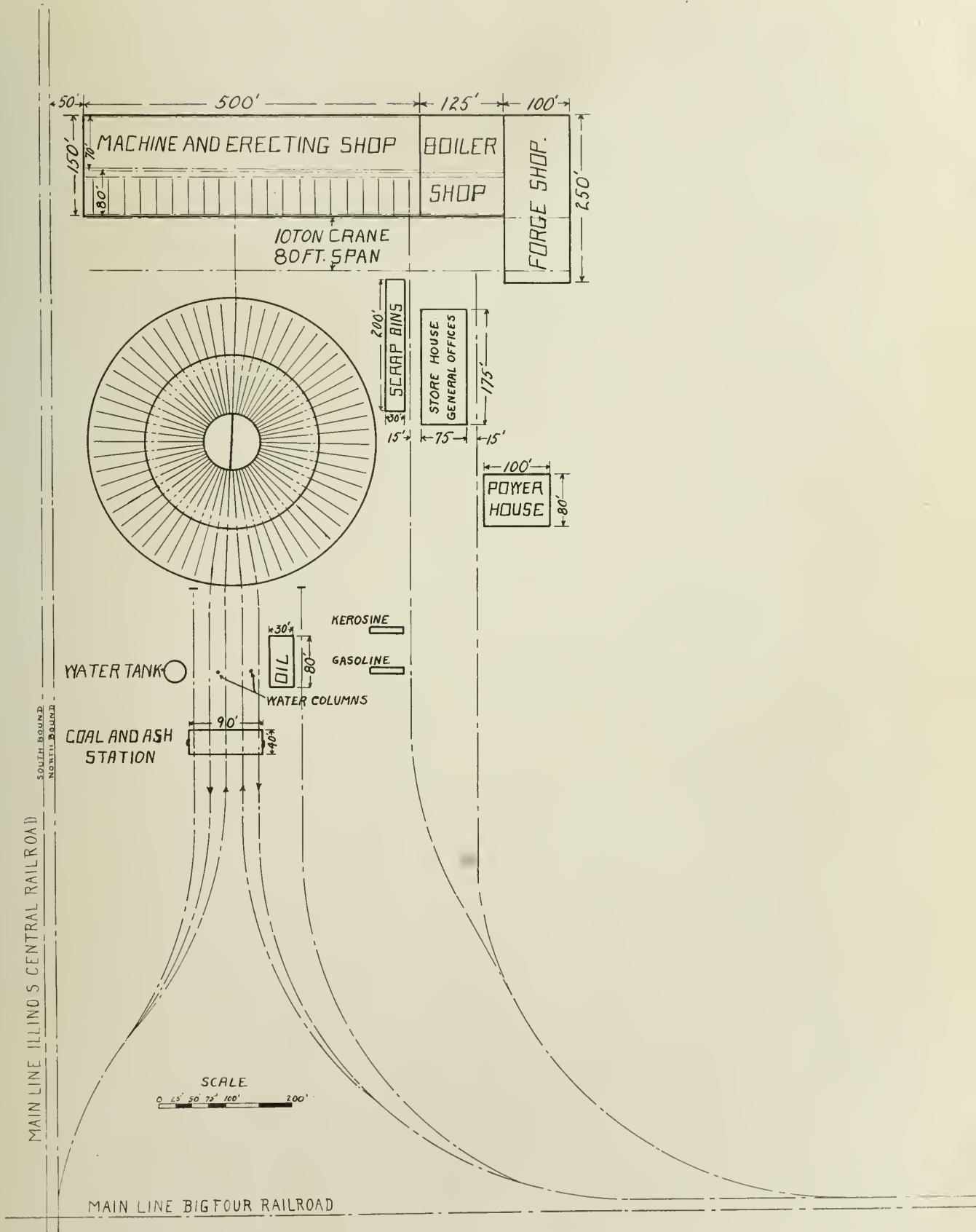


FIG. 1

We have, therefore, unlimited space which readily permits of future extension, and the addition when necessary of a car repair shop with repair and storage tracks.

On the other hand, the land along the Big Four east of the crossing is thickly settled, property values are high, and the location of the shops in this district would necessarily mean the purchase of high priced property to make room for the shops. In the last mentioned location we have less land for a given expenditure and less space for future extensions and for the addition of a car repair shop when necessary.

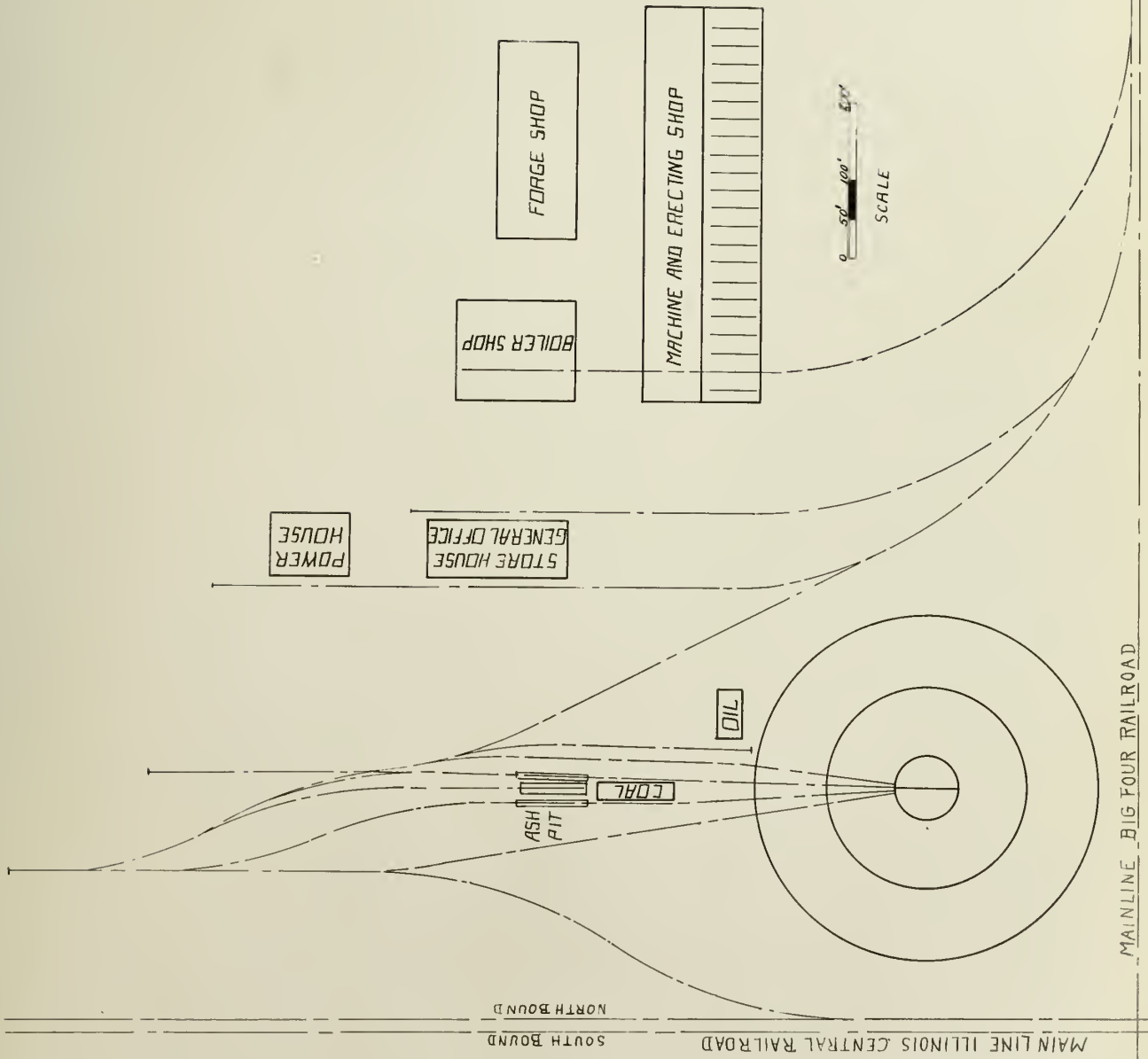
LOCATION AND ARRANGEMENT OF THE SHOPS.

Two general plans covering general shop location were drawn up as in fig. 1 and fig. 2, and before deciding which was the better to use, the possible advantages and disadvantages of each were considered.

The plan shown in fig. 1 was accepted for the following reasons:

The land needed for this plan is less expensive because it is outside of the city limits, and this gives a further advantage in easy future extensions and additions, space being unlimited. The elevation of the land at this location is sufficient to give proper drainage and insure good sanitary conditions.

As the Illinois Central turns about sixty engines per day and the Big Four about fifteen, any advantage of location should be given to the Illinois Central. All freights coming into Champaign whether from the north or south, leave their trains at the south yards. Therefore engines coming from the south yards can go directly into the roundhouse, first passing over the ash pit and then taking coal and water whenever it is desired to



do the latter before going into the house. All Illinois Central freight and passenger engines, whether entering or leaving the roundhouse, can do so directly, saving considerable switching in the movement of engines in and out of the roundhouse.

Passenger engines on the Big Four which will be changed at the Big Four passenger station west of the crossing, can easily get in and out, and freight engines changed at the freight yards in Urbana can enter and leave directly.

The above can be summed up in the one statement that the arrangement of leads in fig. 1 gives a better method of getting engines in and out of the round house than the arrangement shown in fig. 2, and less track and fewer switches are required.

The erecting and boiler shops permit of joint crane service, and the out-door crane can pick up an material from the storage yard (and end of store-house platform) and carry it directly into the blacksmith shop. The advantages of this joint crane service are evident because an important point in any design is the elimination of all unnecessary movement of men and materials in so far as possible. An engine needing light repairs can be run into the erecting shop directly from the round house and a further lead into the erecting shop is obtained by an extension of one of the store-house tracks.

The store-house is convenient to all departments.

The power plant is somewhat isolated but is favorably situated to furnish steam to the blacksmith shop for the hammers, and exhaust steam to the other buildings for heating.

Briefly, the advantages of the layout as shown in fig. 1, over that in fig. 2, are,

1. A better location so far as price and amount of land

available for present and future needs are concerned.

2. A better method of getting into and out of the roundhouse.

3. Joint use of cranes in erecting and boiler shops, and of out-door crane with blacksmith shop.

4. All departments located conveniently with respect to each other, which together with No. 3, eliminates much unnecessary movement of men and materials.

5. Two leads into the erecting ship in case one should be unavailable.

All of which reasons go to show that fig. 1 is the better arrangement and the more compact layout.

ERECTING SHOP.

From the number of engines to be repaired, the time required and to allow for more work in the future, an erecting shop containing twenty-one pits was selected. General practice was followed in the spacing of the pits, this being about twenty-four feet center to center in modern plants, and allowing clearance at both ends, gave a building 500 feet long. The erecting shop was made wide enough to have engines and wheels, after wheeling, on the pit track, space for a longitudinal supply track and proper working room for the heavy machines located under the traveling crane runway. This made the necessary width about eighty feet.

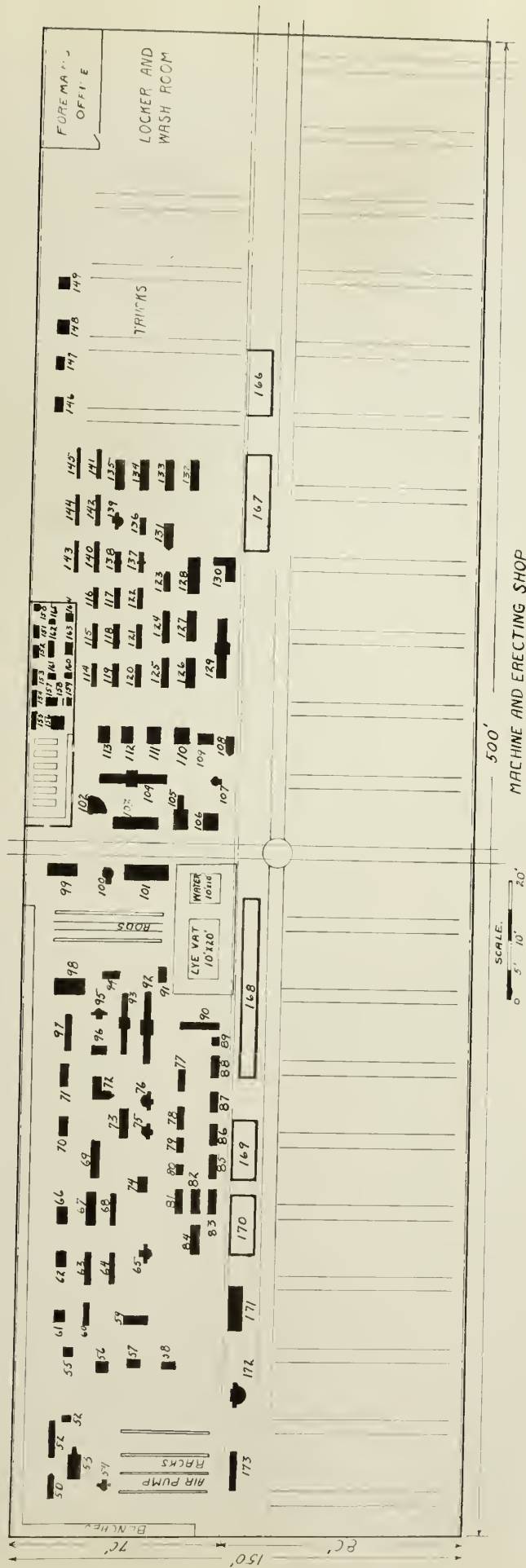
The following considerations led to the adoption of the transverse arrangement of pits.

It is admitted by the advocates of the longitudinal shop that the transverse arrangement is preferable in small shops. The desirability of the longitudinal arrangement even for very large repair shops is open to dispute. The Champaign shop is neither large nor small, but of such size and with such a character of work as to make the transverse arrangement slightly preferable from the standpoint of the usual considerations. In addition to this we have the two following considerations, peculiar to this particular location and local in their application:-- Appointment to positions of shop foreman or superintendent are generally by promotion, and on each of the roads concerned the men have received their earlier training in transverse shops, and can do their best work under conditions with which they are

familiar; the transverse arrangement lends itself the more readily of the two, to the unusually compact and convenient arrangement of locomotive, boiler and blacksmith shop shown.

The erecting shop is served by two cranes, one a 20-ton crane, and the other a 125-ton crane having two carriages of equal strength. The runway of the 20-ton crane is 30 feet above the floor level, and that of the 125-ton crane, 40 feet above the floor level, both runways extending into the boiler shop.

The pits are built of concrete and are 24 inches deep below the rail, 46 inches between the supports for the rail and 40 feet long.



THE MACHINE SHOP.

The first thing determined upon was the square feet of floor space that could be allowed per erecting shop pit in the machine shop. Various installations were referred to to learn approximately what modern practice calls for, and it was found that the number of square feet of floor space per pit varied from about 1400 to 1500. Allowing 1500 square feet per pit, 21 pits require a total floor space of 31,500 square feet. By putting the machine shop and erecting shop together, a symmetrical building was obtained, the machine shop having a total floor space of 35,000 square feet, being 500 feet by 70 feet. The machine shop is served by a 10-ton crane, the runway extending the length of the building.

The practice of grouping machines of like kinds has several advantages. (1). Ease and rapidity of finding an idle machine to do required work. (2). Less unproductive travel. (3). better supervision obtained from gang foreman as he has a smaller area to keep in touch with. (4). Easy location of work when finished.

In the arrangement of the machine shop tools the heavier machines were placed within reach of the erecting shop crane, wheels, frames and other heavy material being handled directly from any part of the erecting shop to the proper machine. Another good practice in the location of machine tools is to place those tools on which a certain class of work is being done near where the raw material is received into the shop. For example, those tools working on castings should be placed near the place that

castings are received into the shop. Sufficient floor space was allowed each machine for proper working room, and for the storage of raw and finished material, leaving room for the free passage of men and material.

The machine shop was divided into a number of sections, work of a certain class being done in each. These sections are, air brake; link and eccentrics; rods; brass; car wheel work; shoes and wedges; and general. In addition there is a space left for the electrical department, a locker and lavatory room for employees, a large roomy office for the shop foreman, and a tool room. These departments were so placed in relation to each other as to obtain the most convenient arrangement.

The air brake department was placed in the corner so as to give plenty of bench room and because much of the apparatus that will be used by the workmen can be hung upon the wall out of the way. Connections are made so that the air pumps when working on tests can discharge the air into the shop system and thus help the main air compressor.

In the link and eccentric and the rod departments, plenty of floor space is needed, as well as room between machines to get in and out with a truck in case the crane is not available, or when the truck can be used to better advantage.

The brass department is located convenient to the rod department because a large quantity of its product is used in the latter.

The truck and car wheel department was placed near the track that led to the wheel storage, the car wheel press, boring mill and lathe being placed conveniently in the department.

The shoe, wedge and box department was so arranged that the

finished product can be placed on a shop car and carried to the part of the shop where they are wanted.

In all of the departments mentioned, with the possible exception of the brass and general departments, the machines are of such a size or are so arranged that individual drive was not only possible but very practical. In the "general" department the advisability of individual motor drive was doubtful, and a few figures were obtained to determine whether or not it was better to use the group drive.

The advantages of a crane over the entire machine department are very evident and the usual group drive would be impossible because of interference with this crane service. One way out of this difficulty was to build a small basement under those machines and put the line shafting, belting, etc., below the floor. The problem is, then, individual motor drive versus group motor drive.

For the section that could be grouped there will be between 90 and 100 horse-power needed with all machinery running and at full power. The International Correspondence School Handbook for Electrical Engineers, 1909, p. 219, says, in part, that the power required to drive the line shafting and belts in a factory where the motive power is all in one source, is about equal to the power required to drive all the machines in the shop at their maximum output. Thus for 100 H.P. required 100 H.P. is lost in friction, whenever shafting is running. On the other hand take individual drive, only 43 H.P. is lost in giving the same output, giving a gain from 50 % to 70 % of useful work at full power. Using a load factor of 30 %, 130 H.P. required running with belts and shafting and 43 with individual drive. Increasing efficiency

from 23 % to 70 %.

On the basis of these figures we will compare the two costs of installation, and of costs for power.

The best grouping obtainable would require a basement 120 feet by 40 feet, and the cost of this to be made water-tight would be

Excavating	840 cubic yards at \$0.30	= \$ 252.00
Cementing Floor	4800 square feet at \$0.13	= 624.00
Cementing Wall	2880 " " at \$0.25	= <u>720.00</u>
		1596.00
Using three motors at \$350.00		= <u>1050.00</u>
	TOTAL COST	\$2646.00

Individual motor drive would require

No. Motors.	H. P. each.	Cost each.	Total cost.
4	1	\$ 50.00	\$ 200.00
13	2	65.00	845.00
5	3	80.00	400.00
8	5	100.00	800.00
1	10	200.00	<u>200.00</u>
	TOTAL COST		2445.00

This gives an advantage to the individual motor drive of \$200.00. This does not take into account the wiring or belting and shafting, but it is our opinion that these will about balance each other in first cost.

Next consider the cost of running the given equipment under both systems. Figures from "Data" on the cost of electrical energy, corrected for relative fuel values and for economy, suggest the basic figure for purposes of comparison of 2.5 cents

per kilowatt hour. Two cases will be used, one with a 100 percent load factor and the other with a 30 percent load factor. Both are to cover a time of fifty hours per week and fifty-two weeks per year.

COSTS BASED ON INTERNATIONAL CORRESPONDENCE SCHOOL FIGURES.

Load	Drive	Horse Power	Cost per KW.	Time	Total	
					Week	Year
Full	Shaft and Belting	200	.025	50	\$250	\$13000
Full	Individual	143	.025	50	178	9250
30 percent	Individual	43	.025	50	54	2800
30 percent	Shaft and Belting	130	.025	50	163	8500
Difference at full power in favor of individual					72	3750
Difference at 30 percent in favor of individual					109	5700

This is also justified by the Union Pacific shops at Omaha, Neb. See Railway Age Gazette, Dec. 2, 1910. When this shop was remodeled and additions made all machines bought were individual drive. The group drive is still used on a few of the old machines which would be very expensive to convert to motor drive, but these are placed under a balcony so as not to interfere with the traveling crane. Because of the individual drive the lathes can be spaced farther apart than would be practicable under the old system.

The space left for the electric department or trucks can be used for future extension, or if necessary an addition can be made by building on the north side.

The tool room was centrally located and well equipped. In the same enclosure with the tool room are placed a number of machines that are used exclusively for tool work except when the foreman can take in some outside work to advantage. Accurate machines are placed in the tool room where the operators will not be disturbed by others.

Individual lockers are provided for the men and by placing these in the lavatory, it is convenient for workmen to remove their shop clothes and wash up before touching street clothes. Rules forbid the keeping of any shop tools in these lockers, drawers being provided in the benches for this purpose. These drawers are equipped with combination locks, the combinations being kept in a book for that purpose by the foreman.

The foreman's office if placed in the center would be ideal, but as he should spend very little time there, the location is not so important. This office was placed in a corner of the machine shop, securing plenty of light, and was also conveniently arranged.

LIST OF TOOLS FOR MACHINE SHOP.*

Layout No.	No. Required	Description	Maker		
PLANERS.					
167	1	12"x 72"x 18' planer for cylinders. Equipped complete. Two heads on cross-rail	Niles-Bement-Pond ('03) p. 173		
168	1	42"x 42"x 32' planer for frames. Equipped as above	Same catalog, p. 162		
104	1	42"x 42"x 12' planer Equipped as above	"	"	p. 162
93 } 129 }	2	36"x 36"x 10' planer Equipped as above	"	"	p. 160
92	1	24"x 24"x 12' planer One head on cross-rail	"	"	p. 156
138	1	17"x 17"x 17" crank planer One head on cross-rail	"	"	p. 155
MILLING MACHINES.					
78	1	#2 hand milling machine with vise	"	"	p. 241
156	1	Universal milling machine with power vertical and cross feeds	"	"	p. 246
53 105	2	Horizontal boring mills	"	"	p. 375 p. 374
139 } 95 } 107 } 75 }	4	37" boring mills Combination jaws on chuck	"	"	p. 262
100	1	42" car wheel, five jaws on table, power crane and power hub-facing at- tachment.	"	"	p. 71

*All tools individual motor drive.

Layout No.	No. Required	Description	Maker	
76	1	51" milling machine	Same catalog, p. 462	
166	1	Cylinder boring mill as there described	"	" p. 430
172	1	84" drive wheel with slotting attachment	"	" p. 472
77	1	2-spindle valve miller		

DRILLS.

159	1	2-spindle sensitive drill		
57	1	4-spindle drill		
123 79 96	3	15" drills		
158	1	20" drill		
50 94	2	26" drills	Same catalog, p. 298	
131	1	36" high duty drill		
108	1	40" drill		
72	1	4 1/2' radial drill without swivel arm	"	" p. 310
102	1	5 1/2' radial drill with swivel arm	"	" p. 312
130	1	6 1/2' radial drill	"	" p. 316

SHAPERS.

111	1	26" shaper, double traveling head	"	" p. 206
66 71 112	3	20" shaper, traveling head, 61-6" bed.	"	" p. 204
161	1	14" shaper	"	" p. 201
62 137	2	12" shapers		

Layout No.	No. Required	Description	Maker	
SLOTTERS.				
110	1	26" slotter		
113	1	18" slotter	Same catalog,	p. 223
109	1	12 1/2" heavy slotter	"	" p. 218
59	1	10" slotter	"	" p. 216
PRESSES.				
173	1	96" 400 ton drive wheel press	"	" p. 506
99	1	48" 200 ton car wheel press	"	" p. 75
103	1	36" 100 ton press for boxes		
165	1	Arbor press		
-----§-----				
171	1	100" quartering machine, right and left hand	"	" p. 51
98 } 106 }	2	Steel plated top tables		
90	1	Tool cabinet for brass foreman		
GRINDERS.				
55	1	link grinder		
61	1	link grinder (Walschert)		
56	1	spiral disc		
58 } 89 }	2	dry grinders		
91	1	wet tool grinder		
70	1	26" disc grinder		
164	1	disc grinder		

Layout No.	No. Required	Description	Maker
150	1	24" tool grinder	
163	1	drill grinder	
80	1	cock grinder	
162	1	Universal tool grinder	
151	1	Automatic tool grinder	
152	1	Universal grinder	
157	1	die grinder	
136	1	grind stone	
74 } 146 }	2	wet stone grinder	

TURRET LATHES.

54 } 65 }	2	36" Vertical lathes	
84	1	Turret screw machine	
81 } 82 } 83 }	3	2" x 24" lathes	
88	1	24" Universal lathe	
133 } 134 } 135 }	3	3 1/2" x 24" lathes	
132	1	6 1/2" X 26" lathe	
		-----§-----	
148	1	Triple bolt cutter, 2" maximum	
149	1	Double bolt cutter, 1" maximum	
147	1	Nut facer	

LATHES.

155	1	14"--6' lathe	
154 } 153 } 60 } 68 }	6	16"--10' lathes (Portable)	

Layout No.	No. Required	Description
142 } 143 } 144 } 145 }	4	16"--10' lathes
140 } 141 } 51 } 64 }	4	18"--10' lathes
86	1	20"--6' lathe
114 115 116	3	20"--8' lathes
63	1	20"--10' lathe
117 } 118 } 119 } 120 } 121 } 122 }	6	24"--8'
85 } 87 }	2	24"--8' cabinet lathe
69	1	24"--12' lathe
97	1	27"--12' lathe
124 } 125 }	2	28"--10' lathes
73	1	36"--7'6" lathe
126 } 127 }	2	36"--10' lathes
101	1	42" car wheel lathe
128	1	48"--12' lathe
169	1	84" drive wheel lathe
170	1	100" drive wheel lathe
67	1	Cap--10' lathe

THE BOILER SHOP.

The boiler shop is unlike the machine shop in the fact that it does not admit of classification into a few types. A great variety of cross sections may be used and many combinations of length and width. The requisites are floor space in proper proportion to the number of locomotives to be handled, proper provision of crane facilities and sufficient tool equipment.

It has been found that it is an advantage to have the erecting shop and boiler shop so located and related that they would have joint crane service. By this arrangement the time and amount of handling of materials is reduced to a minimum. Among locomotive shops having this arrangement are the Norfolk and Western, Roanoke, Va.; Atchison, Topeka and Santa Fe, Topeka, Kan.; Canadian Pacific, Montreal, Can.; Central Railroad of New Jersey, Elizabethport, N. J.; and Pennsylvania and Reading, Reading, Pa.

This arrangement was adopted in the plan of the repair shop at Champaign. The boiler shop is placed at the east end of the erecting shop, and is simply an extension of the erecting and machine shops. A wall separates the boiler and machine shops, and to allow for the joint crane service a rolling steel door is placed between the erecting and boiler shops.

Joint crane service is had between the erecting and boiler shops, and to further aid in the transfer of material between the two shops, the longitudinal track is extended into the boiler shop.

The next step after having determined upon the location of the boiler shop was to determine the square feet of floor area

required to handle properly the work to be done. To do this, a certain number of pits in the boiler shop was assumed, good practice being to have about a fourth of the number of pits in the erecting shop. As to the number of square feet of floor space per pit, practice varies, there being no general recognized rule for the determination of such. Berg, in his "American Shop Railway Systems", p. 57, gives a table showing the square feet of floor space per erecting pit used in various railway boiler shops over the United States and which vary from about 600 square feet to 3000 square feet. The class of work done in these different shops ranges from only light repair work in some, to repair work together with building of engines in others, such as the Juniata shops of the Pennsylvania.

Five pits were thought to be sufficient to handle properly all the work to be done, and allowing 893 square feet per erecting pit, with 21 pits, we had a total floor space of 18,750 square feet. As one dimension was fixed at 150 feet, the final dimensions of the boiler shop were 125 feet by 150 feet.

The five pits provided in the boiler shop were thought to be sufficient to handle all the work that was not done in the erecting shop, and also some tank work. Two cross tracks, provided with six foot turn tables, extend into the north end of the shop. These are generally used for the transfer of material, flues, etc., but in cases of necessity can be used for tank work.

The pits are spaced 26 feet 3 inches center to center.

THE SELECTION OF BOILER SHOP TOOLS.

In the selection of the boiler shop tools care was taken to select those that could handle properly the work to be done, no unnecessary tools being included on the list. The tools were obtained from reputable firms.

ARRANGEMENT OF TOOLS.

Modern practice of installing machinery of like kind together has proven effective in handling and performing work, as the material to be machined can be delivered to the section of the shop where they are installed often saving a second handling.

As most of the machines in the boiler shop are individually motor driven, a very flexible arrangement is secured and future additions of machines can be easily made. In arranging the machines in the boiler shop the heavier machines were placed on a line under the crane runway. This allowed the heavy work to be handled by the small crane directly to the machines. The flanging furnace and clamps were placed in the northeast corner of the shop. Here there is sufficient room and light, and being provided with a jib crane , is easily accessible to the track.

The flue machines are placed in the north side of the boiler shop and between the two tracks that extend up into this end of the building. Flues to be repaired are placed on a push car and carried down the longitudinal track to the cross track that runs to the flue rattler. They are then placed in the rattler, and having gone through the various operations, end up

with the flue tester near the second cross track. The flues may then be easily placed on a push car and transported to any part of the boiler or erecting shop.

The tin shop is placed in the northwest corner of the boiler shop, allowing easy communication between the two. It is well provided with tools and benches and the cross track gives a convenient means for the movement of any material to or from the other shops.

LIST OF THE BOILER SHOP TOOLS.

No.	Description	Maker
1.	1 Flanging Furnace 16' x 14'	
2.	1 Flange fire	
3.	1 Forge	
4.	1 Power clamps, 15 '	
5.	1 24-inch throat punch	Joseph T. Ryerson, No. 260 p. 255.
6.	1 60-inch throat punch	Joseph T. Ryerson, No. 260 p. 255
7.	1 15-foot bending rolls	Niles-Bement-Pond, p. 553
8.	1 Lenox rotary bevel shear	Joseph T. Ryerson, No. 2 p. 199
9.	1 Punch and shear and 25-foot spacing table	Niles-Bement-Pond, p. 573
10.	1 Plate planer	Joseph T. Ryerson
11.	1 Flue rattler	Joseph T. Ryerson, p. 346
12.	1 Flue cutter	Joseph T. Ryerson, p. 345
13.	2 Ferguson's welding machines	Joseph T. Ryerson, No. 1, p. 207
14.	1 Ryerson furnace	Joseph T. Ryerson, p. 385
16.	1 Sledger	
17.	1 Flue tester	
18.	1 Four spindle drill	Niles-Bement-Pond
19.	1 6-foot radial drill	Niles-Bement-Pond

Tin Shop Tools.

20.	1 Wall drill	Joseph T. Ryerson, p. 296b
21.	1 Heavy square shears	Joseph T. Ryerson, p. 330
22.	1 Slip rolls, 98" between housings	Joseph T. Ryerson, p. 375

No.	Description	Maker
23.	1 Circular shears	Joseph T. Ryerson, 04, p. 333
24.	1 Forge and anvil	
25.	1 1/2" to 2" pipe machine	
26.	1 1" to 4" pipe machine	
27.	1 Pipe bending machine	
28.	1 Press	
29.	1 Heavy brake	

THE BLACKSMITH SHOP.

LOCATION.

The blacksmith shop was placed at the east end of the boiler shop. Here it is convenient to the boiler house. The yard crane runway is extended into the shop and by this arrangement heavy material from the erecting shop, yard, or end of storehouse platform can be easily handled into the blacksmith shop. The transfer of materials between the erecting, boiler and blacksmith departments is facilitated by extending the longitudinal track into the blacksmith shop, a six foot turn-table provided, and the track laid to each end of the building.

FLOOR AREA.

In the case of the blacksmith shop it is difficult to determine the proper floor space because it can not be referred to any one unit. The boiler shop is engaged almost exclusively on locomotive work, whereas the blacksmith shop is used jointly on work for locomotives and repair work for passenger and freight cars. Work for the maintenance of way department is also frequently handled in the blacksmith shop. The exact amount of floor space for any projected plant can be approximated only after consideration of all the facts bearing on the individual case. The work to be done at Champaign will be locomotive repair work with some light car repair work. In the blacksmith shop there will be located the heating coils and fan, lavatory and the foreman's office. Allowing sufficient working room for the machines, room for future additions and a storage space for raw materials, a building 250 feet long and 100 feet wide, giving 25,000 square

feet of floor space was thought to be satisfactory.

SELECTION OF TOOLS.

In the selection of tools for the blacksmith shop the same general principles as in the selection for the machine and boiler shops were kept in mind, namely, to select the proper tools to do the work, eliminating all unnecessary tools, and purchasing the tools from reliable firms. As most of the heavy repair work and manufacturing will be done at Burnside, the size and number of tools for the Champaign shops can be reduced.

ARRANGEMENT OF TOOLS.

The tools for the heavy work, such as the bulldozer and the steam hammers, were placed in the south end of the building where they can be served by the yard crane. This arrangement will aid in the quick and easy handling of heavy material into and out of the blacksmith shop. Separate jib cranes are provided for the bulldozer, the 4000 pound and the 700 pound steam hammers. Besides the forging furnaces for these two hammers, each is served by an open furnace and used for large work. The bolt and nut machines and alligator shears are placed in the west side of the building next to the boiler shop. Here they will be convenient to material brought in on a push car from the machine or boiler shops. Raw material from the storage space can be handled easily to any part of the shop, or if necessary, to the boiler or machine shops, on the push car.

A number of fires or hand forges are placed conveniently around the shop.

The steam for the power hammers is piped directly into the blacksmith shop from the power house. The mains will run under-

ground to the hammers, a branch then running up to the steam cylinder of each. This arrangement does not interfere with the movement of the traveling crane.

LIST OF BLACKSMITH SHOP TOOLS.

No.	Description	Maker
31.	1 Forging furnace,-2 doors,- 5' deep by 7' long for No. 32	
32.	1 4000 pound steam hammer	Niles-Bement-Pond
33.	1 Forging furnace,-1 door,- for No. 34	
34.	1 700-pound steam hammer	Niles-Bement-Pond
35.	1 Forging furnace,-1 door,- 9' by 3' for No. 36.	
36.	1 Bulldozer, size D.	National Machine Co.
37.	1 1 1/2-inch heading-Upset- ing-Forging	National Machine Co., p. 143
38.	1 1 1/2-inch alligator shear	National Machine Co.
39.	1 Forging furnach for No. 37	
40.	1 1 1/2-inch triple bolt cut- ter	National Machine Co., p. 108
41.	1 1-inch triple bolt cutter	National Machine Co., p. 108
42.	Staybolt cutter--1 1/2" double	National Machine Co., p. 104
43.	1 1 1/2 " six spindle nut tapper	National Machine Co.
44.	1 Forging furnace for No. 45	
45.	1 200-pound steam hammer	Niles-Bement Pond
46.	2 Open furnaces for large work	

THE STOREHOUSE.

The storehouse is a two story brick building, 175 feet long by 75 feet wide. The store is on the first floor, the second floor being used for offices.

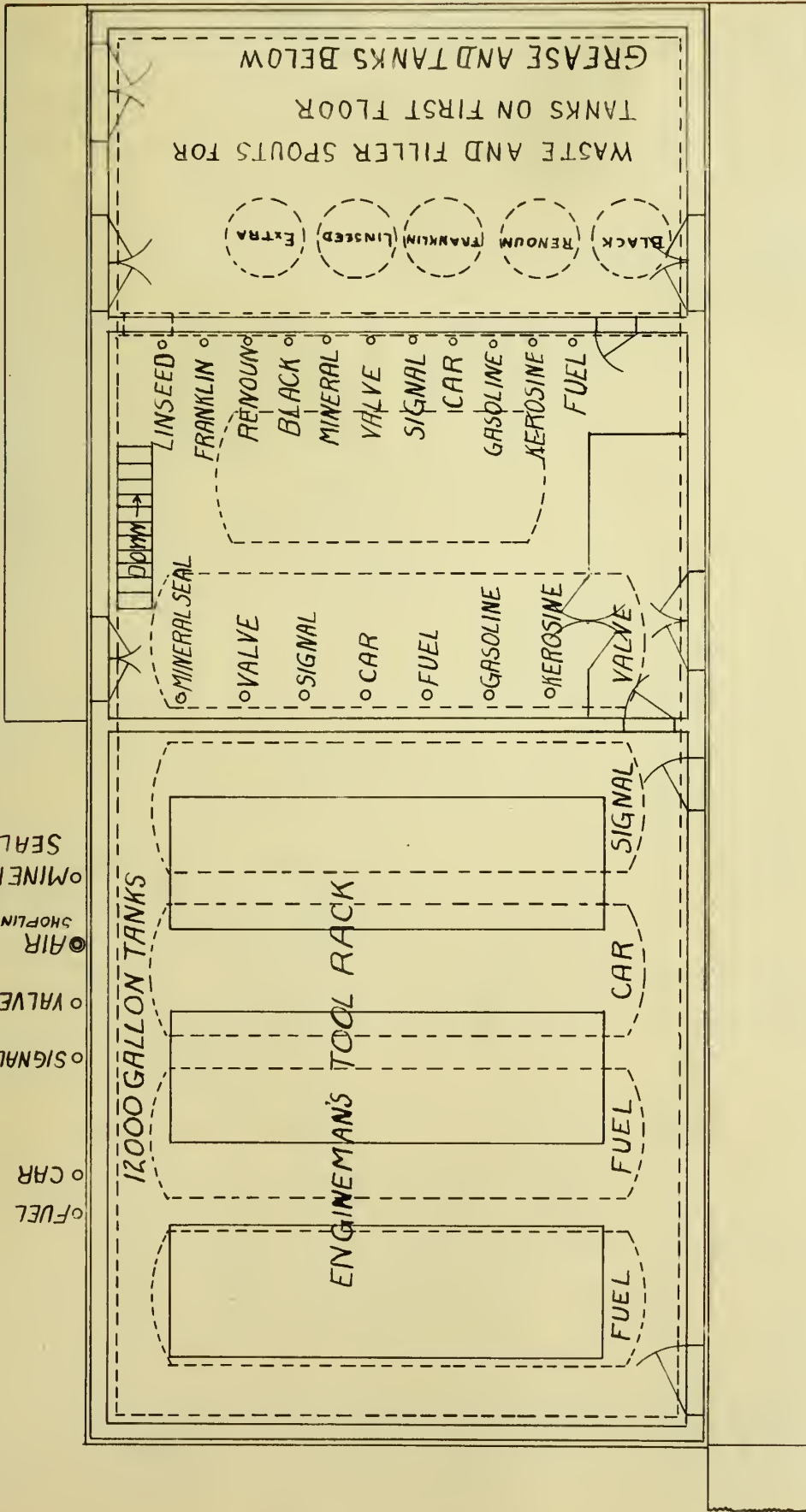
This building is located between two tracks, one being used for a receiving and the other for a shipping track. Between each track and the building is a ten foot loading platform which is elevated to the level of a standard box car floor. The north platform is approached by an easy incline and its end is served by the yard crane.

The storekeeper's office is located on the first floor in a convenient place for supervision. The rest of the room is arranged for the convenience of handling supplies, so as to cause the helper the least travel for the articles in the most demand. The shelving is so arranged as to give a good light in all parts of the storeroom, articles being easy to find.

Metal shelving is used to eliminate as much as possible the danger of fire. It is also more substantial than wooden shelves.

CENTER LINE OF TRACK

○ FUEL
○ CAR
○ SIGNAL
○ VALVE
○ AIR
○ SHOPLINE
○ MINERAL
○ SEAL



CENTER LINE OF TRACK

THE OIL HOUSE.

The oil house building is brick, one story high, with concrete foundation and a concrete roof. The floor is of reinforced concrete. No wood or other inflammable material was used in the construction of this building.

In the basement are located the storage tanks for all oils except kerosene and gasoline. These two are stored in elevated tanks located about 100 feet east of the oil house, convenient to one of the storehouse tracks, and about 50 feet apart. They are filled by putting air pressure on the tank cars and forcing the oils into the elevated tanks. It then flows by gravity into the oil house. The other storage tanks are placed low enough so that they can be filled by gravity from the cars. The oil then flows by gravity into a smaller tank holding about fifty gallons. This tank is capable of withstanding air pressure great enough to force the oil to the faucets on the first floor. An automatic valve is placed between the large and the small tanks to permit filling and to prevent air escaping into the larger tank.

In the other room of the basement there are placed five tanks of 500 gallons capacity each, room being left also for the storage of grease.

The first floor is divided into three rooms. The south room is used for waste, having a storage capacity of a little over a carload. In this room there are also located the filler plugs for the tanks below, which are filled from barrels.

The middle room is for the handling of oil in small quantities, a barrel or under. Along one side of the room is a row of faucets to fill barrels only. These are for only those oils

which are bought in car lots. Those which are bought in barrels need not be refilled for shipping purposes, taking a barrel out of storage rather than filling one from one of the 500 gallon tank.

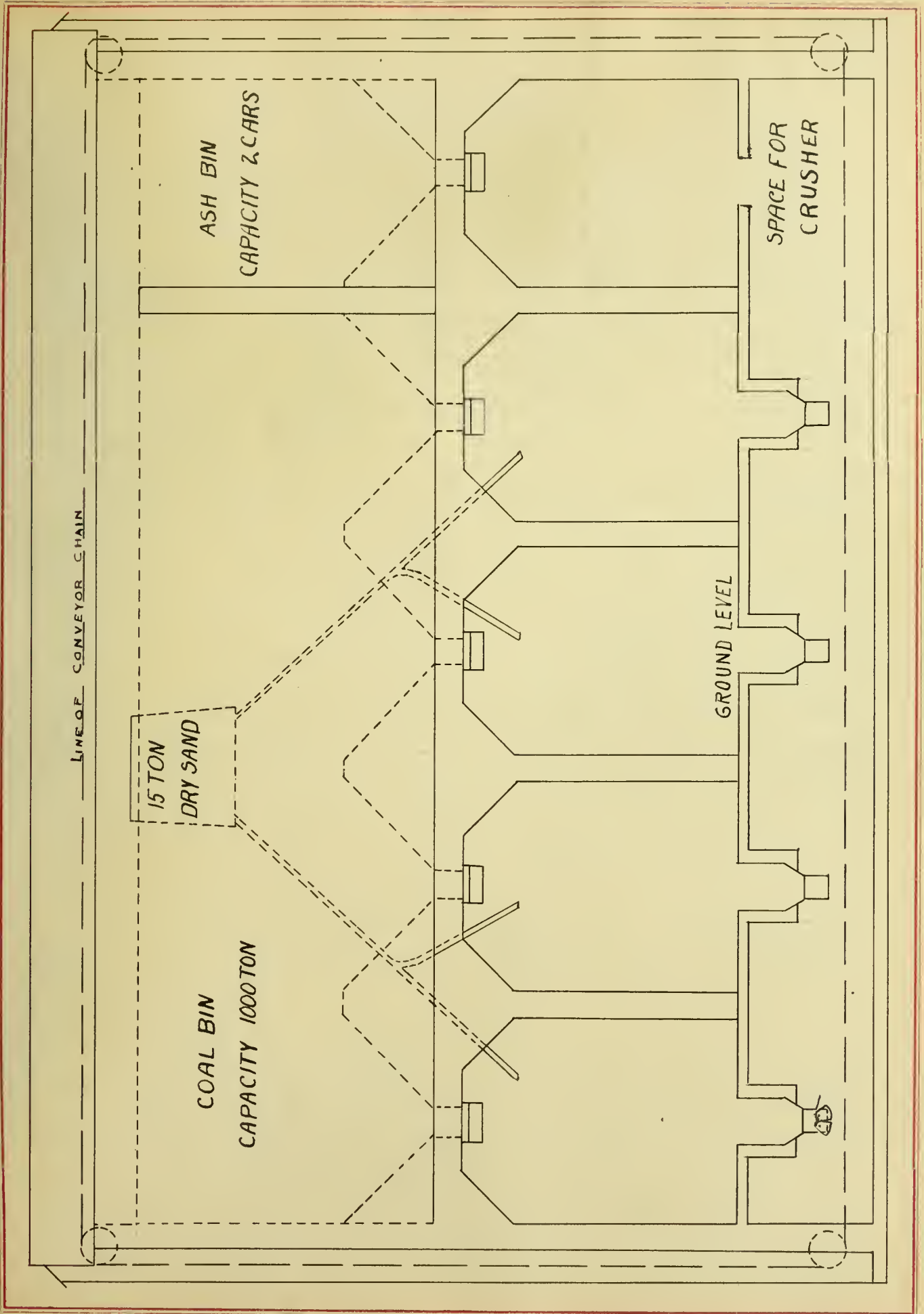
On the other side of the room is a row of faucets for drawing out oils in small lots only, one faucet being used for each kind of oil. Under each faucet is a drip pan to catch any oil that might be spilled, and this oil is returned to the storage tank. A railing is placed across the room to remind the employees that only the attendant is to measure out any oil.

Since the engines will be "pooled", the tools that belong to one crew must be removed and those of another crew substituted for the next trip. A storage place therefore is needed for the tools not in service. The north room of the oil house offers a suitable place for this, it being close and convenient to engines going both in and out of the round-house. Tools are brought in from the engine on its arrival and placed in a locker until they are wanted again.

There are platforms on both sides of the building along the tracks, making it convenient for unloading and loading barrels and other supplies. There is an incline up to the platform on the west of the building for the wheeling of the engineers tools in a wheelbarrow to or from the locker room.

For fire protection, high pressure steam pipes are arranged in the building so as to completely flood it with steam and thus smother the fire. Two quick opening valves are used, one located in the middle room of the oil house and the other at a safe distance from it, both so arranged that either will put full steam pressure in the pipes independent of the other. The ground around

the outside tanks is graded so that the oil would be confined to a restricted territory in case of fire and explosion of tank. These tanks are each equipped with a pipe containing a wire gauge, which would prevent fire from going inside but still allows air to enter or leave as outside temperature raises or lowers, causing expansion or contraction of the liquid. This pipe, which acts as a safety valve, has its open end down to prevent water from entering.



THE COALING STATION.

In order to lessen the fire risk and also secure a more substantial building, the coaling station was made of reinforced concrete throughout. It occupies a ground space of 98 feet by 40 feet and is 54 feet high above the track level. The building covers five tracks. With 18 feet center to center, four being used for coaling and cleaning of grates and one for bringing in coal and removing the ashes.

A Peck conveyor is used, having 30 inch by 30 inch buckets with 30 inch pitch. This conveyor will handle 110 tons of coal per hour at a working speed of 40 feet per minute. The coal is stored in a large bin covering the four coaling tracks, and its sides are sloping, terminating in a hopper bottom over each of the four tracks. The coal is allowed to drop on a chute, which is overcounterbalanced so as to keep it out of the way of engines. The coal bins have a storage capacity of over 1000 tons and allowing ten tons per engine with eighty engines per day, there is storage capacity for thirty hours.

This gives a cheap method of handling coal, two men being able to unload the cars, coal the engines and keep the conveyor in operation.

The conveyor is operated by a 20 horse-power direct current motor. Connected also to this motor are the crusher rolls which serve two purposes: first, to hold up the weight of the coal when a car is dumped and allow only enough to fill a bucket as each passes; second, to reduce any lumps to a four inch size or under.

Since its capacity is not overcrowded the ashes are handled

by the coal conveyor, alternating with the coal so as to keep the ash pit clean as much of the time as possible, and thus not delay engines. The ashes are stored in a bin directly over the ash loading track. This bin is equipped with chutes and checks as are the coal bins. The ashes are handled dry until placed in the car, then wet if necessary to keep them from burning the car. The ash bin has a capacity of over two cars.

For convenience the sand storage tank is placed in the coal house and piped over each coaling track. The sand is placed in the tank by air. This is not an economical method, but is better and cheaper for the quantity of sand that is used here than an elevator would be. The air also serves as a second sifter by removing any pebbles that may have passed through the screen.

The tank has a capacity of fifteen tons of dry sand.

THE ROUNDHOUSE.

The roundhouse is a brick building with concrete foundations. It is 430 feet in diameter and contains 51 stalls. The length of these stalls is 80 feet, an 80 foot turn table being provided with a lead of 90 feet between turn table and entrance to stall.

It is equipped with a complete boiler washing and refilling plant, benches and vices, a lavatory, lockers, tool room and the foreman's office.

The pits are of concrete, 40 feet long, 30 inches deep and 46 inches wide. They are heated by a steam coil along one side and air and water connections are conveniently located to each pit. All pipes as far as possible are placed in sight.

The roundhouse is lighted by a number of electric lights placed near the ends of each floor space with numerous extra sockets and extensions.

A rectangular "smoke jack" is used because of the ease in spotting the engines under them.

THE YARD STORAGE.

The yard storage is located under the yard crane runway and extends to the west end of the erecting shop. This gives a yard about 500 feet long and 80 feet wide, and is paved with brick. Such things not needing to be stored under roof are stored here. The yards crane can load or unload any material on cars that are run in on the storehouse track.

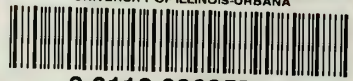
THE SCRAP BINS.

The scrap bins are placed west of the storehouse and convenient to the track. They are 200 feet long and 20 feet wide, with a 10-foot platform, which the yard crane can serve, at the north end. An easy approach leads up to the platform to allow the wheeling of scrap from the different shops to the bins.





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